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20 January 1964

D-ATMOSPHERICS

INTRODUCTION

In reconnaissance photography from satellites, the quality of the result vitally depends on three different aspects of the atmosphere: (1) Extent of cloud cover which completely obscures the ground; (2) Atmospheric scattering which reduces the modulation (contrast) of the scene; and (3) Atmospheric turbulence which makes the atmosphere optically inhomogeneous. These points are discussed below.

CLOUDS

Clouds obscure the ground completely, and it is, therefore, highly desirable to operate cameras when there is minimal cloud cover. Presently, about 50% cloud cover is normally experienced in C/M operation, this using a polar orbit weather satellite to cancel, by real time command, some planned passes on the expectation of very high obscuration. The target take of the C/M program is directly related to the target density per frame times the percentage of the ground viewed. It is inescapable that higher takes are related to the lower cloud cover. Since C/M is film bound, the implementation of weather forecasts with any significant skill level will increase~~d~~ the ground coverage and also the "take". It is certainly true that, on occasions, targets can be seen through holes ~~bales~~ in an otherwise overcast sky, but, a priori, holes are ~~that hale is~~ randomly distributed and the decision to take on that basis will cost film and eliminate the coverage over another target area with much larger holes and several times the probable target take.

The use of weather forecasts are limited to the degree of freedom in the operation and can only be employed when this freedom exists. When priorities [redacted] STAT

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are extremely high, this freedom is removed, as is, also, the question of using forecasts. But, when the freedom of operation exists, the optimum use of the weather forecasts should be employed. On the other hand, the quality of the weather forecasts is currently at a modest skill level and improved reliability would be highly beneficial. This is not only because of the direct benefit of increasing the viewed areas but the increased confidence in the part of the operator would expand the frequency of their usage.

[redacted]

ATMOSPHERIC SCATTERING

The modulation reductinn caused by atmospheric scattering (haze) is extremely variable in magnitude. If the distribution was well known, allowance could be made for it in the design performance predictions for every camera system. It would then be possible to more accurately compare different systems on a basis of both probability of target resolution and interpretability. However, there is no urgent necessity to disect the very complex physics of the real atmosphere to describe haze, since the probability distribution can be observed directly and it alone is the important aspect.

The most desirable basis for predicting the probability distribution of haze would be based on an accurate physical model. This might relate modulation reduction to meteorological conditions for instance. While it is not now clear that this can be done in a completely satisfactory way, if for no other reason than the atmosphere's lack of isotropy, a promising approach is discussed in Appendix (B) .

[redacted] write-up)

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Fortunately, the facet that is critical is neither the physics of the situation nor the relationship of modulation reduction and meteorological conditions. All we care about is the probability distribution of modulation reduction and this can be directly obtained intwo ways. First, targets of known reflectance can be photographed and the distribution of results will yield the desired probability distribution. To be meaningful, this is likely to be a program similar to, but more extensive than, Project Photorek* carried out at Wright-Patterson AFB. The second approach is less accurate, but the comparison of operational photography with carefully prepared GEMS will, at least, roughly sort the distribution of modulation reduction into broad categories. A combination of both approaches provides a valuable consistency check.

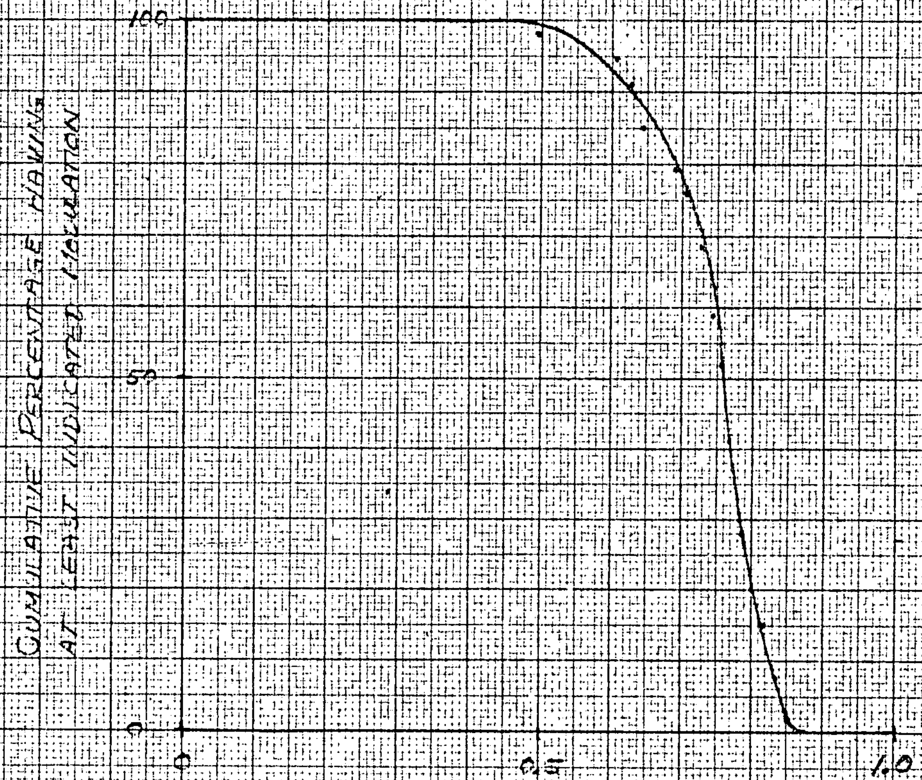
The magnitude of modulation reduction can be estimated from Project Photorek* flights at 50,000 feet, which is over most of the atmosphere. Figure _(1)__ shows the ogive of modulation reduction of a high contrast target in "fair" weather for the spectral region of interest. The modulation reduction will be more severe when integrated over the broader sample of meteorological conditions experienced by the C/M system and, also, more severe for typical scenes since these have a lower albedo than a high contrast target, as shown in Figure_(2)__. The data in Figure _(1)__ are reasonably consistent with the prediction made by a radiated energy balance model of the atmosphere, as discussed in Appendix _(B)__ .

ATMOSPHERIC TURBULENCE

Atmospheric turbulence causes the index of refraction to vary irregularly along the optical path. By making several assumptions, it is possible to

*A Study of Photographic Contrast Attenuation by the Atmosphere, ASD-TDR-63-541 (Sept 63)

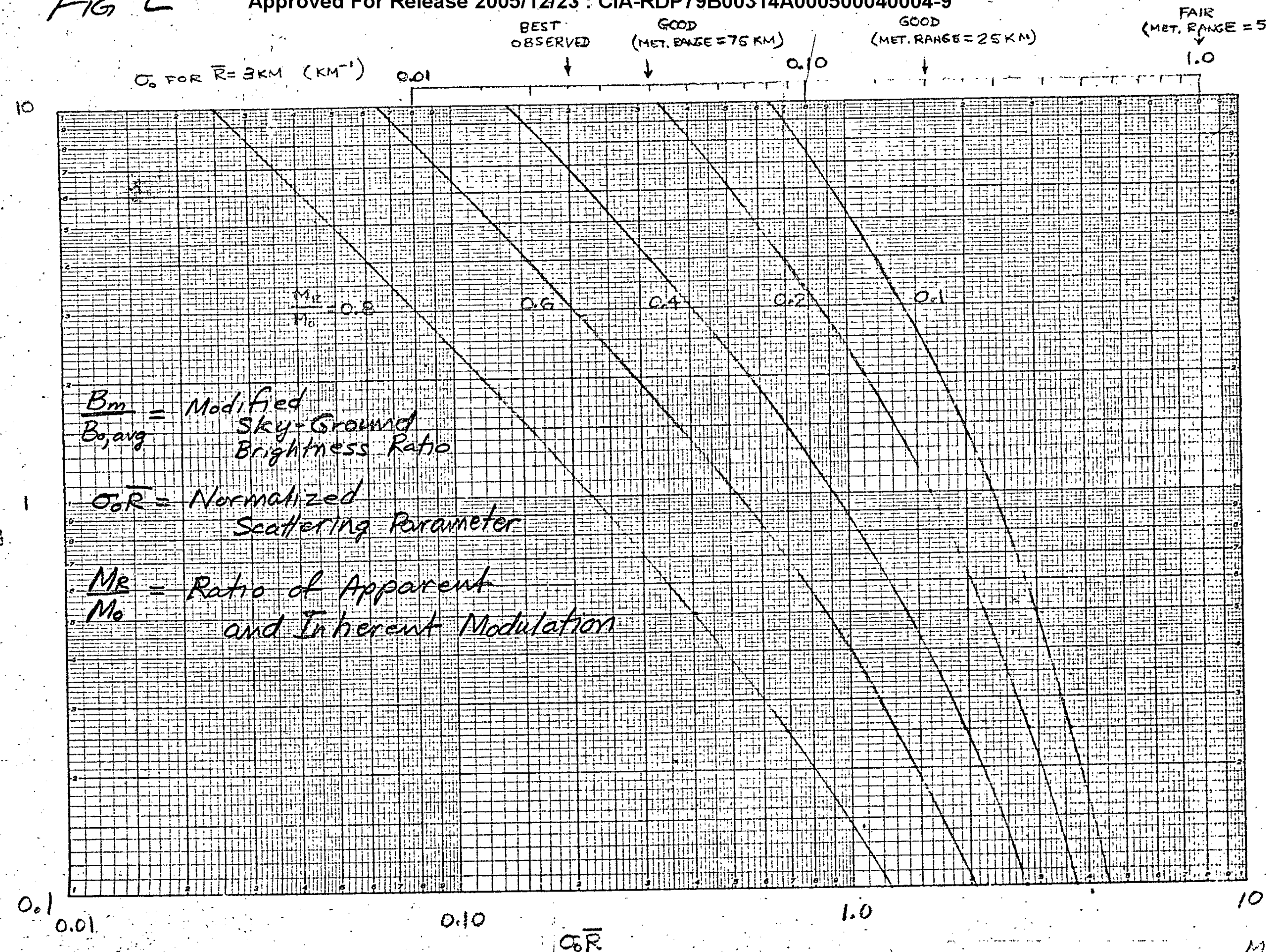
FIG 1



APPARENT MODULATION OF
HIGH CONTRAST USAF
TRI-BAR TARGETS FROM
50,000 FT IN "FAIR" WEATHER
USING YELLOW FILTER

McRosen

FIG 2



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estimate the average magnitude of this effect, as shown in Figure _(3)__. In this case, the modulation reduction is a function of the size of the ground detail, unlike the case of atmospheric scattering. For C/M photography, atmospheric turbulence is not expected to be important. (For G photography, the effect may be of importance, but there is no obvious way to distinguish it from other random image degradations.)

RECOMMENDATIONS

Continuation of Photorek* haze reduction histograms

Research on tie between meteorology & haze

TOP SECRET

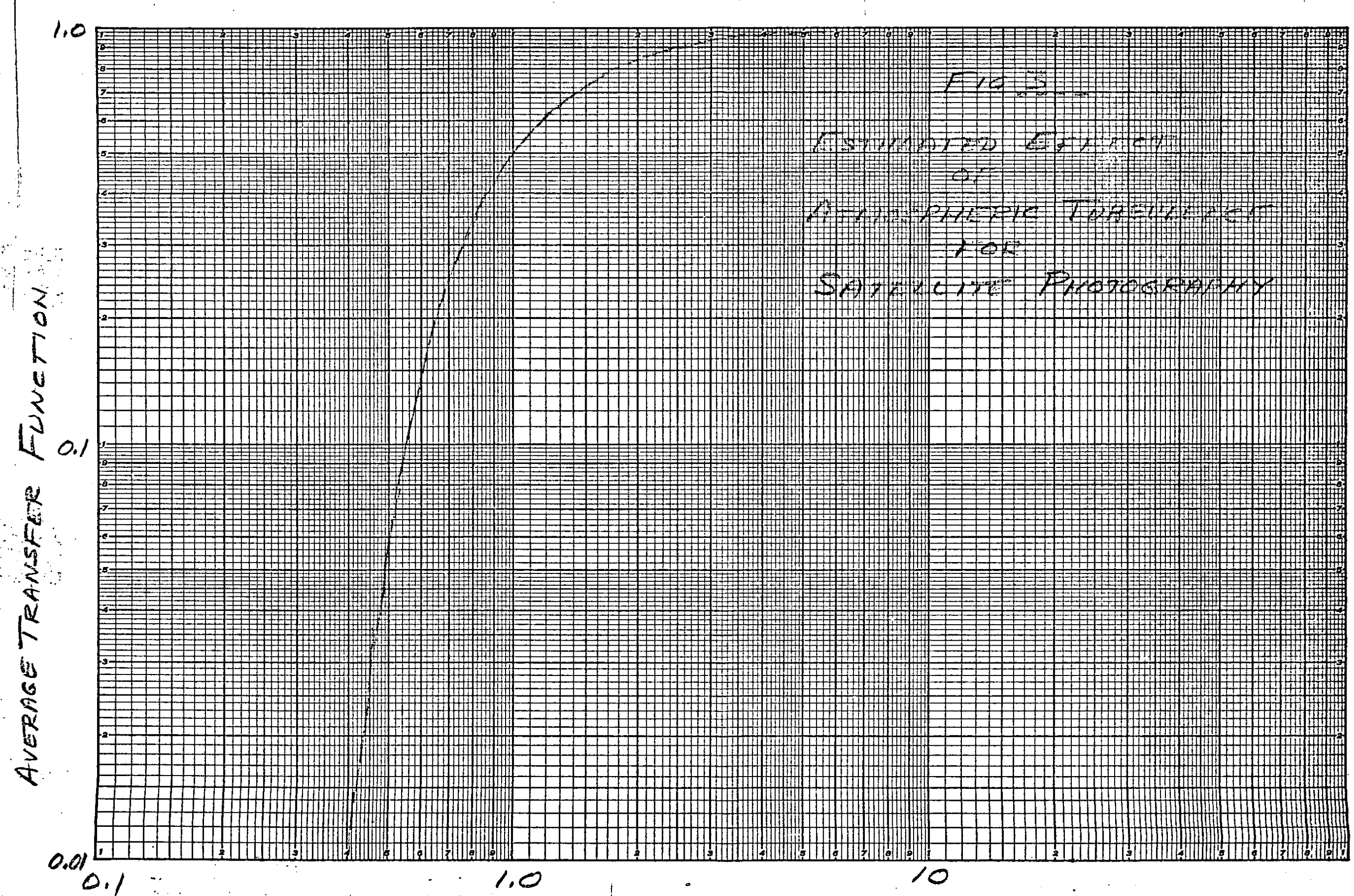
FIG 3
ESTIMATED EFFECT
OF
ATMOSPHERIC TURBULENCE
FOR
SATELLITE PHOTOGRAPHY
AVERAGE TRANSFER FUNCTION
1.0
0.1
0.01
0.1
1.0
10
SPATIAL PERIOD ON GROUND (FT.)